CONCENTRIC RING GRABEN COMPLEX IN HAASTTSE-BAAD TESSERA, NORTHERN APHRODITE TERRA (VENUS): ENDOGENIC VS EXOGENIC ORIGIN AND IMPLICATIONS. I. López[1] and V. L. Hansen[2], [1]Departamento de Biología y Geología. Universidad Rey Juan Carlos, 28933, Móstoles. Spain (ivan.lopez@urjc.es), [2]Department of Geological Sciences, 1114 Kirby Drive, University of Minnesota Duluth, Duluth, MN 55812 (vhansen@d.umn.edu).

Introduction: Ribbon Tessera Terrain (RTT) constitutes Venus's locally oldest surface unit [1], although globally not all RTT formed at the same time [2-3]. Unit RTT, marked by a distinctive tectonic fabric and high surface roughness, characterizes crustal plateaus but also occurs as lowland inliers, widely interpreted as remnants of collapsed crustal plateaus [4-5]. The RTT tectonic fabric commonly includes short- to long-wavelength folds (1–50 km) that record layer shortening, and orthogonal structures that record layer extension, so-called ribbon structures; flooding accompanies all stages of RTT evolution [6-7]. Graben complexes record the youngest deformation recorded in RTT, typically postdating formation of adjacent short- to long-wavelength folds and ribbons; graben complexes show local embayment, in some cases flooding marks intratessera graben, in other cases flood units might be contiguous with the adjacent lowland units, including shield terrain. Graben complexes in RTT define broad orthogonal patterns [6], radial patterns [8], or parallel trends [9]. In this work we describe a suite of concentric ring graben that postdate, or form later during, ribbon tessera fabric formation in Haasttse-Baad Tessera, northern Aphrodite Terra; we provide a initial review of possible forming mechanisms.

Data: Geologic analysis was carried out using NASA Magellan S-band synthetic aperture radar (SAR) and altimetry data [10]. Data include: 1) full resolution (75-100 m/pixel) right- and left-illuminated SAR); 2) Magellan altimetry (8 km along-track by 20 km across-track, ~30-m average vertical accuracy); and 3) synthetic stereo images constructed after [11] using NIH-Image macros developed by D.A. Young. SAR data, obtained via USGS Map-a-Planet website, was viewed in normal and inverted modes.

Description of the feature: The concentric ring graben complex is partially located in Haasttse-Baad Tessera (Fig. 1), which lies north of, and at a lower regional elevation than, crustal plateau Thetis Regio, which straddles the equator. The composite structure, herein informally referred to as the *Haastte-Baad ring complex (HBRC)*, is composed of a series of well-defined concentric, nested, arcuate troughs that cut local RTT structures, and maintain a spacing of ~10-50 km [12]. These concentric graben differ from RTT graben complexes in that the graben walls, or fault scarps, are singular structures, rather than suites of faults, which characterize RTT graben complexes. In addition, the concentric graben, although curved in planform, have significantly larger length:width ratios than graben complexes; concentric graben length depends on the location of the graben, and the along-structure continuity—due, in part, to late flooding.

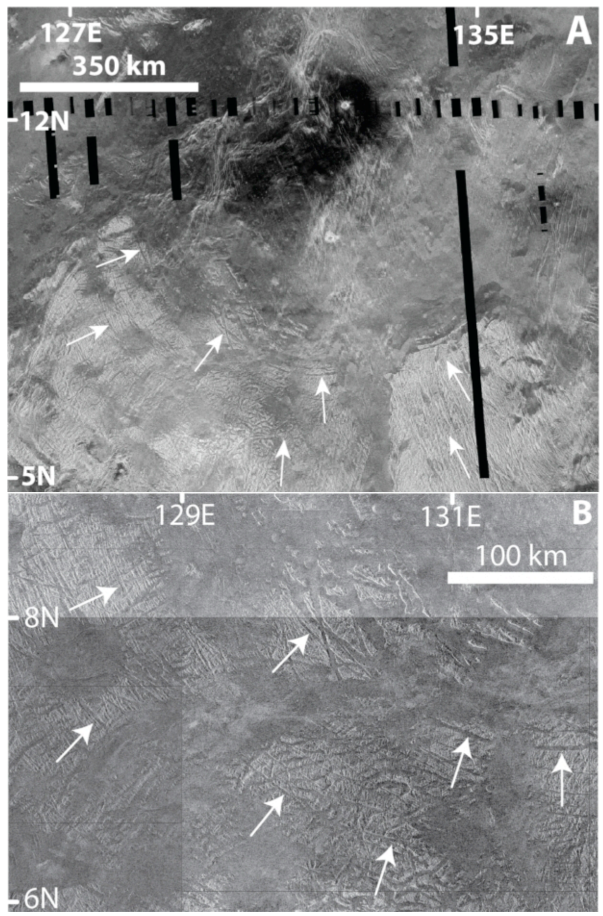

Fig. 1. SAR images of the Haastte-Baad ring complex, with arrows marking the positions of concentric graben; A) southern part; B) SW-quadrant, note simple graben structure.

The *HBRC*, with a diameter >1000 km, is well-defined within its southern half, which cuts Haasttse-Baad Tessera (Fig. 1A), but poorly defined in its northern half, where RTT exposures occur only as isolated kipukas in the lowland. Some late, possibly concentric trough structures that cut RTT kipukas north of Haasttse-baad Tessera could be part of the *HBRC*, although the isolated nature of RTT kipukas prevent clear delineation of structural continuity. Concentric graben, which vary in number and spacing, are best developed, or preserved, in the SW-quadrant compare to the SE-quadrant, which is dissected by a suite of NNW-trending graben that likely dominantly post-date the concentric graben suite.

Modes of origin: The different models that might explain the formation of concentric ring graben structures observed in other planetary bodies can be grouped as related to magmatic (endogenic) and bolide impact (exogenic) processes.

Endogenic models. Concentric suites of extensional structures occur spatially associated with coronae, large tectonovolcanic features. Coronae, widely accepted as the surface signature of magmatic mantle diapirs, occur mostly in chains, although they occur as isolated features in the lowlands [13]; they are, however, uncommon in association with crustal plateaus, where the thickness of the lithosphere is thought to inhibit a surface manifestation of mantle diapirs [14]. Thus the *HBRC* could have formed after Haasttse-Baad Tessera lost subsurface support, or perhaps, the tessera never had subsurface support to existed as a crustal plateau [15]. It is also possible that some coronae represent impact features formed on thin lithosphere [16].

Similar concentric fractures also occur, although at a different scale, related to the formation of volcanic calderas or paterae, wherein a crustal magmatic reservoir is depleted of magma, resulting in collapse of the central block and formation of a downsag caldera accompanied by formation of concentric ring faults [17].

Exogenic models. Similar structures, so called Valhalla-type ring structures, preserved on Jupiter's icy satellites (e.g., Europa's Callanish and Tyre craters; Fig. 2), have been interpreted as multiring impact structures formed by bolide impact in a thin elastic layer that overlies a low-viscosity layer [18-20], which is further underlain by a strong substrate [21]. The number, spacing and morphology of the concentric graben are related to thickness and strength of the elastic layer and crater diameter [21-22].

Discussion: The *HBRC* is very different in terms of morphology and size to concentric graben suites formed by endogenic processes. In the case of a coronae-scenario, *HBRC* would be a new class of coronae formed exclusively on tessera terrain. There is no evidence for volcanic materials spatially related to the *HBRC* as would be expected in a endogenic scenario that calls for emptying of a huge magmatic chamber prior to caldera and ring complex formation.

On the other hand, formation of the *HBRC* as a multiring impact basin on a crust marked by a thin elastic layer above a low-viscosity channel, has strong implications for the geology and crustal structure of the target area, and therefore to the current debate on the origin of both ribbon tessera terrain and crustal plateaus. The possible recognition of a new type of impact crater on Venus is also important for the impact record and the geologic history of Venus.

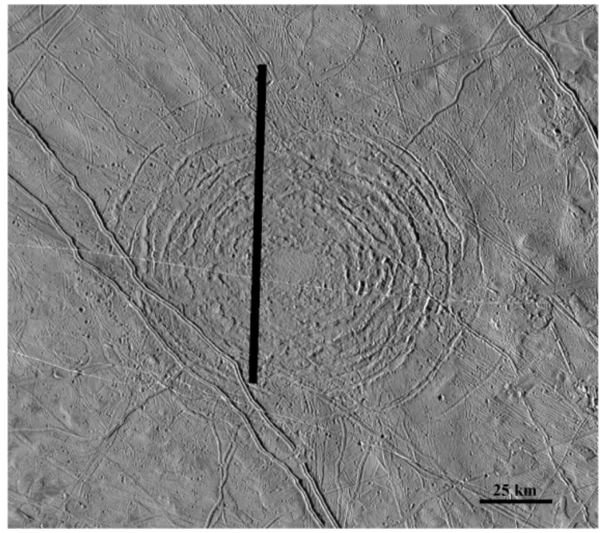

Fig. 2. Tyre crater. Europa.

Conclusions and further work: A large (>1000 km) ring graben complex is located in Haasttse-baad Tessera, Venus. Models for its formation include: a) endogenic origin due to emplacement of a mantle diapir into earlier formed RTT, or caldera collapse on a huge scale, previously unrecognized; and b) exogenic origin by bolide impact on a crust that rheologically consists of a thin elastic layer overlying a low-viscosity (semi-molten?) layer above a strong substrate. It is necessary to complete detailed structural mapping of the area and its topography and explore in detail the different working hypothesis and their implications for the origin of RTT and crustal plateaus.

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